CHAPTER 1

INTEGRATIVE REPORT:
THE DISTRIBUTIONAL IMPACT OF
MONETARY POLICY IN SEACEN ECONOMIES

By
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1. Introduction

This research project aims at studying the distributional impact of monetary policy on SEACEN economies, with focus on Cambodia, India, Mongolia, Philippines, Sri Lanka, Chinese Taipei, Thailand and Vietnam. The impact of monetary policy on inflation and GDP growth has been extensively investigated, but the distributional impact has been more or less overlooked, until the question of the role of monetary policy in affecting the income and wealth distribution came into the spotlight again in the recent years.

During the last 25 years, many advanced economies (AD), as well as several emerging economies (EME), have adopted inflation targeting to control the general rise in the price level, as price stability has been found to be a prerequisite for sustained economic growth as well as full employment. Indeed, most countries have experienced a stable inflation coupled with low volatility, leading to the era of the Great Moderation. When inflation rates are high, households and companies face difficulties in making financial decisions, as large fluctuations in inflation affect the real value of debt, investments and savings. Under high inflation rates, savers are negatively affected as they receive a lower real value of the assets they hold, and borrowers have a clear advantage given by a lower real debt to repay. As inflation rates around the world have been quite low and stable, the distributional impact has become of lesser interest. However, the new frontiers in research have shown a strong impact of monetary policy on rising asset prices, which contribute to the increasing income and wealth of households belonging to the top of the income distribution. Thus, the question on the distributional impact of monetary policy is again an important topic to investigate.

The idea that an expansionary monetary policy can exacerbate inequality has become popular again since the global financial crisis. The post-crisis period has been characterized by very low interest rates and persistent low inflation rates. This situation is common to both ADs and EMEs countries. The concern about exceptionally low interest rates stands on the fact that they tend to induce soaring equity and real estate prices, thus increasing income and wealth of savers. Therefore, income and wealth are being redistributed towards the already very wealthy households. However, the impact of monetary policy on income and

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wealth distribution is rather difficult to disentangle. Different transmission channels work contemporaneously. On the one hand, an expansionary monetary policy leads to a gain for households holding equities and other types of assets, as the underlying prices increase. On the other hand, an interest rate cut leads to a reduction in interest payments for borrowers, who are made better off. Conversely, savers are made worse off as they receive lower net interest income. However, income comes from two main sources: wages as remuneration to the labor and profits as a remuneration to capital. An expansionary monetary policy boosts employment and increases wages. Firms also experience larger profits. Finally, monetary policy affects inflation, and thus the real value of nominal debt. High levels of inflation tend to reduce the real value of debt and deposits. Moreover, there are some homogeneous channels, such as aggregate income and substitution channels, that affects income and wealth with the same sign across all households, and heterogenous channels that affect different types of households with a different sign. The substitution effect is concerned about how households respond to unexpected changes in the interest rate in the intertemporally substituting between consumption and saving, while the aggregate income channel implies an increase in households’ expenditure and firms’ investment stimulating output, employment and wages after a monetary easing. Auclert (AER, 2019) refers to them as the earning heterogeneity channel (related to the labor and profit earnings), Fisher channel (related to changes in price level) and interest rate channel. The last channel is very important as lower real interest rates tend to increase financial asset prices. However, as specified by Auclert (AER, 2019), the winner and loser of asset holdings are defined by the duration and maturity of their assets and liabilities. For example, households holding short-term deposits would have a positive unhedged interest rate exposure, while those who hold long-term bonds or adjustable-rate mortgage liabilities would have a negative unhedged interest rate exposure. Thus, an expansionary monetary policy would distribute wealth from the households with negative interest rate exposure to those with positive exposure.

This research project aims at investigating how monetary policy contributes to the income and wealth distributions of the SEACEN-8: Cambodia, India, Mongolia, Philippines, Sri Lanka, Chinese Taipei, Thailand and Vietnam. However, for various economies, it is difficult to obtain data on income and wealth across the five-quantiles. Thus, most of the research will focus on the Gini Coefficient, which indicates the dispersion of the income inequality, meaning that the Gini Index measures the degree of inequality in the distribution of family income in an economy. The more nearly equal an economy’s income distribution, the lower its Gini Index.

In order to understand the distributional impact of monetary policy, this chapter will show results on the responses of the Gini Coefficient based on a Panel VAR estimation. Due to data limitation for the SEACEN-8, this empirical strategy will focus only of income distribution, proxied by the Gini Index. Several experiments are run in order to highlight the distributional impact during the last 10 years, comparing periods of pre-crisis and post-crisis, and showing the different impact in case of expansionary and contractionary monetary policy. Results show that an expansionary monetary policy tends to lower the Gini Index, while an contractionary policy raises it. However, the order of magnitude is quite different, revealing a clear asymmetric effect. Moreover, the inflation channel is very important, as the Gini Index tends to decrease by less when the inflation response to an expansionary monetary policy is weak. Also the response of the Gini Index is less pronounced when the GDP is not expanding much, indicating the importance of the aggregate income channel. Finally, the Panel VAR
analysis shows that the asset price channel is also very important, as the Gini Index response to an expansionary monetary policy has a similar path to the response of asset price, and this is more evident when the model includes housing price.

The chapter also offers an overview of the short-term interest rates and inflation rates in the SEACEN-8. Most of the economies have been experiencing ultra low inflation rates, coupled with downward trending policy rates. An interesting question is understanding how monetary policy affects income inequality given the historical low inflation levels. Chinese Taipei and Thailand are two very good example of such a situation. Moreover, these economies have shown a flat policy rate for a prolonged period.

Finally, I develop a dynamic stochastic general equilibrium (DSGE) model for a small economy to show how a technology shock is transmitted to the rest of the economy when the central bank change the policy rate to ensure price stability, in comparison with a situation where the policy rate is very low. Results show that the distributional impact is contained when the policy rate channel is shut down. A VAR model applied to Chinese Taipei shows that the results of the DSGE model are robust, as a temporarily technology shock tends to decrease income inequality with a lower magnitude when the interest rate channel is not at work.

It is not easy to identify all the transmission channels through which monetary policy affects income distribution. While the Panel VAR analysis can highlight the importance of inflation and asset prices channels, and give directions of the sign of the Gini Index, the DSGE model is more informative in terms of various transmission channels, even if such a model has limitations in identifying all possible channels described in the recent literature.

The chapter is developed as follows. Section 2 describes the recent economic development in the SEACEN-8. Section 3 gives an overview of the transmission channels in the literature review. Session 4 estimates a Panel VAR model to show the impact of monetary policy on the Gini Coefficient. Session 5 delves into the development of a DSGE model for a small open economy to highlight the transmission channels of monetary policy shocks on income and wealth distribution. Session 6 discusses the implications of a monetary policy shock on an environment that accounts for the ultra-low interest rate or zero-lower bound. Session 7 discusses policy implications and concludes.

2. Economic Developments in the SEACEN-8

This section offers a brief overview of some fundamentals in the SEACEN-8 of Cambodia, India, Mongolia, Philippines, Sri Lanka, Chinese Taipei, Thailand and Vietnam. Figure 1 shows that the policy rates (i.e. short-term interest rates) have trended down in many SEACEN economies in the recent years, compared to the pre-crisis period. Since 2016, the short-term interest rate has been below its historical level in these economies, except for Mongolia and Sri Lanka, which show higher policy rates in the last 2 years relative to 2016. Moreover, Chinese Taipei, Philippines, Thailand and Vietnam have experienced unchanged policy rates for some prolonged lengths of time during the post-crisis period.

3. In many SEACEN economies, long-term interest rates have declined since 2000, a period in which long-term inflation expectations have been quite stable.
Figure 2 displays five-year moving averages of the growth rate of real per capita GDP for the 8 economies of interest. Since 2010, many economies appear to be growing more slowly over time. However, for some economies there is no clear trend in the growth rate, such as Chinese Taipei, Thailand, Vietnam, and for a few economies, growth seems to be increasing as in India and in the Philippines. Mongolia and Sri Lanka display a downturn only after 2014, thus a clear slowdown in the last 4 years.

**Figure 1**
**Short-Term Interest Rates**

![Interest Rates Graphs](image)

Sources: CEIC Database. Philippines and Thailand: BIS Policy Rate Statistics.

Figure 3 displays inflation rates in the SEACEN-8 economies. In every case, inflation in 2018 was below its historic average, often by a considerable amount. In 2018, inflation was below 5 percent in all the SEACEN-8; below 3 percent in 4 economies; and below 2 percent in 2 economies. In Chinese Taipei and Thailand, inflation was below zero in 2015. In most of the economies with very low inflation rate after 2015 — Cambodia, Chinese Taipei, Thailand, and Vietnam — GDP growth slowed markedly over time. In these economies, there was probably a gap between actual and potential GDP growth at some point either before or when inflation was declining. A key priority for monetary policy in Asia should be keeping inflation from falling persistently below 2 percent and possibly even targeting a rate slightly higher than 2 percent.
In order to gain more insights, the case of Thailand is instructive. Figure 3 shows that Thailand is at risk of falling into sustained deflation. With the policy rate at 1.5 percent, the Bank of Thailand would not be able to deliver the 2-percentage point easing of conventional policy as it did during the global financial crisis. Moreover, the policy seems to be too tight as the core inflation is falling further below target.

Figure 4 describes the path of the nominal exchange rate, expressed as the value of local currency to one US$. All the SEACEN economies show a currency depreciation versus the US dollar over time, except for Thailand. Cambodia, however, has been dollarized for very long time, thus the exchange rate has been flat since the 2000. Chinese Taipei shows a clear depreciation between 1995 and 2000, after that the exchange rate shows periods of alternation between appreciation and depreciation.

Finally, Figure 5 reports the evolution of the Gini Coefficient, expressed in terms of disposable income, over the period 1975 until 2017. The Gini Index indicates the dispersion of income inequality, meaning that the Gini Index measures the degree of inequality in the distribution of family income in an economy. The more nearly equal an economy’s income distribution, the lower its Gini Index.
Figure 3
CPI Inflation Rates (Percent Per Year)

Source: CEIC Database.

Figure 4
Nominal Exchange Rate (Local Currency to One US$)

Sources: CEIC Database. Data are normalized to 100 in 1994:Q1, and expressed in natural log.
Figure 5 reveals a certain degree of heterogeneity, as many economies show a decreasing trend in the Gini Index, such as Cambodia, the Philippines and Thailand, while an increasing trend in India, Sri Lanka and Vietnam. Chinese Taipei shows an increasing Gini Index until 2010, but after that the Gini Coefficient decreased. Mongolia instead presents a quite stable index. Moreover, India, Philippines, Sri Lanka, Thailand and Vietnam show a very high Gini Index, indicating large poverty rates and larger income dispersion, with India and Sri Lanka outpacing the others at 45 percent. On the other hand, Mongolia and Chinese Taipei have the lowest average Gini Index, below 35 percent, which is comparable to the level observed in many advanced economies. Finally, it has to be noted that most of the SEACEN-8 economies show a lower Gini Index in the most recent period, which corresponds to ultra-low interest rates.

**Figure 5**

Gini Index, Disposable Income (1975-2017)

Sources: The Standardized World Income Inequality Database (SWIID – Frederick, 2019).

The goal of this chapter is to identify how monetary policy influences the Gini index described in Figure 5. Recent theoretical developments have highlighted the direct and indirect effect of monetary policy transmission in explaining developments in income and wealth inequality.\(^4\) The direct effect works through a change in the interest rates on households, as an intertemporal substitution (lower interest rates boost aggregate demand by stimulating consumption and investment), while the indirect effect works through changes in prices, wages and unemployment. Thus, changes in policy rates by central bank affect inflation, real interest rates and real wages. However, in recent years, it has been shown that inflation has become less responsive to domestic demand pressures in many SEACEN economies. Indeed, the argument that inflation is beyond the control of central banks is questionable, putting concern on the evolution of the distributional impact of monetary policy on the SEACEN-8. The very low trend rates of inflation, occurring since the global financial crisis, coupled with downward nominal wages and price rigidity have contributed to a flattening of the Phillips

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curve in the SEACEN-8 region. The Phillips curve indicates the strengthening of the economy, and it is associated with increasing inflation. However, the SEACEN-8 region shows only modest pickups in inflation, indicating that the Phillips curve relationship has weakened. The Phillips curve relationship depends on many economic factors, and the flattening may have been caused by a change in the way monetary policy responds to inflation and economic conditions. Another possibility is that something fundamental has changed in the economy, for instance the openness of the economy to foreign trade or the way firms set wages and prices.

The statistical Phillips curve takes the form of a regression of the difference between the current quarter’s inflation, \( \pi_t \), and the previous year’s average inflation, \( \bar{\pi}_{t-1} \), on the output deviation, \( \hat{y}_t \), and a constant:

\[
\pi_t - \bar{\pi}_{t-1} = \alpha + \beta \hat{y}_t + u_t
\]

where \( \beta \) is the regression coefficient, \( \alpha \) is the constant, and \( u_t \) is the error term. Notice that \( \bar{\pi}_{t-1} = (\pi_{t-1} + \pi_{t-2} + \pi_{t-3} + \pi_{t-4})/4 \).

The regression coefficient, \( \beta \), is the slope of the Phillips curve. If the slope is positive, inflation tends to rise above its previous-year average level when output is higher than its steady state, and inflation tends to fall when output is lower. If the slope is negative, the opposite relationships tend to hold.

Using data for Thailand, Figure 6, left Panel, shows that the estimated regression coefficient \( \beta \) is 0.69662, meaning that annualized inflation tends to rise by 0.7 percentage points above its average level in the previous year for each percentage point that output is higher than its steady state. Focusing on a more recent period, Figure 6, right Panel, indicates a clear flattening of the Thai Phillips curve, as now the estimated regression coefficient \( \beta \) is 0.408, meaning that annualized inflation tends to rise only by 0.4 percentage points above its average level in the previous year for each percentage point that output is higher than its steady state.

Table 1 presents the slope of the Phillips curve for the SEACEN-8 over two periods: 1994-2019 and 2010-2018. For all 8 economies, the slope of the Phillips curve has been lower since 2010, except for the Philippines. This indicates that a flattening of the curve is also occurring in the SEACEN-8, as with many advanced economies.

So far, we see slow economic growth with ultra-low inflation and policy rates in many of the SEACEN-8 economies. Many economies appear to be growing more slowly over time. However, for some economies, there is no clear trend in the growth rate and for a few economies, growth seems to be increasing. Moreover, it can be argued that monetary policy has only a weak impact on inflation, as reflected in declining estimates of the slope of the Phillips curve, and that easy monetary policy encourages risky behavior in financial markets. The ultra-low inflation and persistent negative output gaps themselves raise risks to financial stability. The question is now to understand how monetary policy affects income and wealth inequality during periods of such ultra-low inflation and policy rates.
3. Transmission Channels of the Distributional Impact of Monetary Policy in the Literature

Monetary policy affects the income and wealth distribution in various ways, and this section is going to explore the transmission channels affecting decisions of heterogeneous households. An expansionary monetary policy lowers interest rates and increases aggregate demand, thus boosting economic growth. It also lowers the value of the currency, thereby decreasing the exchange rate. Lower interest rates stimulate investments, which have a positive impact on firms’ profits and labor market, in the form of higher wages and lower unemployment. This represents the *income earnings channel*. In general, labor income represents the most important source of income for households in the lower and middle parts
of the income distribution, while capital income mainly influences the income of the top of the distribution. However, monetary policy affects labor earnings in different ways: the young middle-class benefits more from higher wages because the younger are more likely to work than older households and also because their job prospects tend to be more pro-cyclical. The Fisher channel, when there is the unexpected rise in inflation due to an expansionary monetary policy, benefits nominal debtors while making worse off nominal creditors. For instance, households with relatively large mortgage debts will be better off, but households renting apartments will be at a disadvantage.

The net interest income channel reduces interest payments for borrowers who are better off, while decreasing income that savers receive on their deposits. The net financial wealth channel affects the value of asset and equity prices. As the asset prices increase for lower interest rates, $p_t = (1/R_t)$, holders of these assets gain, including housing prices. However, the impact of monetary policy on households’ income and wealth through financial assets can be heterogeneous depending on the duration and maturity of their balance sheet. For example, households holding short-term deposits would have a positive unhedged interest rate exposures, while those who hold long-term bonds or adjustable-rate mortgage liabilities would have a negative positive unhedged interest rate exposure. Thus, an expansionary monetary policy would distribute wealth from the households with negative interest rate exposure to those with positive exposure.

As the distributional impact of monetary policy has attracted public attention, a lot of research has been devoted to this topic in recent years. Dobbs et al. (2013) showed that prolonged cuts in policy rates generate large benefits for younger households that are net borrowers, while leading to income loss for older households holding interest-bearing assets. Ampudia et al. (2018) shows that the distributional impact of monetary policy has important indirect effects depending on the employment status, where lower interest rates tend to reduce unemployment rates and increase labor income. This effect is found to be quantitatively important in reducing inequality in the Euro Area. Heterogeneity across households is very important in understanding the distributional impact of monetary policy. Recent literature has shown that monetary policy can have opposite effects across various types of agents: young versus old (Wong, 2016), savers versus borrowers (Doepke and Schneider, 2006), and the financially constrained versus the unconstrained (Williamson, 2008).

More recently, Kaplan et al. (2018) introduced the Heterogeneous Agent New Keynesian (HANK) model in which households holding large liquid assets are able to smooth transitory shocks in their consumption, while ‘hand-to-mouth’ households holding little liquid assets have a large marginal propensity to consume, and thus are much more sensitive to transitory shocks. Moreover, Kaplan et al. (2018) also introduced a new category: ‘wealthy’ hand-to-mouth households. These households can hold a sizable amount of wealth in the form of an illiquid asset, such as real estate asset. Similar effects are found in Auclert (2019), Beraja et al. (2017) and Coibion et al. (2017).

Another strand in the literature focuses on the the prices faced by households of different incomes. Indeed, households consuming goods based on sticky-priced goods are less sensitive to changes in inflation, relative to households who consume mainly goods set at flexible prices. See Nakamura and Steinsson (2008), Boivin et al. (2009) and Almas (2012).
While most of the literature on the distributional impact of monetary policy has been focused on advanced economies, very little has been devoted to emerging and Asian economies. Park (2017) studied the housing market and household balance sheets in South Korea over the period 2001-2012. Park (2017) found that the share of “wealthy hand-to-mouth” households that hold little liquid wealth while owning a large amount of illiquid assets is very high in South Korea, compared to advanced economies. Moreover, wealth in South Korea is mainly concentrated on illiquid assets (i.e., housing and real estate assets). Cui and Feng (2017) analyze data from the China Household Finance Survey in 2012 and found that wealthy hand-to-mouth represent most of the hand-to-mouth households in the People’s Republic of China. Taghizadeh-Hesary et al. (2018) analyzes the effect of zero interest rate policy and negative interest rate policy on income inequality in Japan during the period of 2002Q1 to 2017Q3. They find that quantitative easing (QE) and quantitative and qualitative easing (QQE) policies implemented in Japan lead to significant increases in income inequality.

Away from the focus on households, Domac (1999) analyzes credit and monetary policies in Malaysia and investigates the distributional impact of monetary policy on small- and medium-size industries and large manufacturing firms. Domac (1999) finds that monetary tightening in Malaysia disproportionately affects small and medium-size enterprises.

There has been no prior work investigating the distributional impact of monetary policy in the SEACEN-8, and this chapter will fill this knowledge gap.

4. **Empirical Analysis – Panel VAR**

In this section, I develop a Panel Vector Auto Regression (Panel VAR) model for the SEACEN-8 economies under consideration in this project. The sample period range from the first quarter 2000 until the first quarter 2017. The following system is estimated:

\[
Y_{it} = AY_{it-1} + BX_{it-1} + u_i + e_{it}
\]

where \(Y_{it}\) is a \((k \times 1)\) vector of dependent variables, \(X_{it-1}\) is a \((1 \times 1)\) vector of exogenous covariates, \(A\) is a \((k \times k)\)-dimensional matrix of the VAR coefficients on lagged domestic quantities and \(B\) is a regression coefficient to be estimated. \(u_i\) and \(e_{it}\) are \((k \times 1)\) vectors of dependent variable-specific panel fixed-effects and idiosyncratic errors, respectively. For all \(t > s\), \(E(e_{it}) = 0\), \(E(e_{it}e_{s}^\prime) = \Sigma\), and \(E(e_{it}e_{st}^\prime) = 0\) for \(t < s\).

I use the General Method of Moments (GMM) to estimate the Panel VAR, which regresses each endogenous variable on its own lag(s) as well as the lags of all other variables in the system. Following Love and Zicchino (2006), I apply forward mean differencing or orthogonal deviations (the Helmert procedure) to remove the fixed effects; all variables in the model are transformed in deviations from forward means (see Arellano and Bover, 1995).

To identify the shocks, the Cholesky’s decomposition of the covariance matrix is adopted, which assumes a recursive exogeneity structure. Therefore, the first variable in the VAR is only affected contemporaneously by the shock to itself; the second variable in the VAR is affected contemporaneously by the shocks to the first variable and the shock to itself, and so on.
The endogenous variables included in the Panel VAR are: real GDP, inflation, short-term interest rate, exchange rate, current account (percent of GDP) and the Gini Index. All variables are expressed in log, with the exception of the short-term interest rate and the current account, which are expressed as a percentage of GDP. The model selection has included one lag.5 The model also includes exogenous controlling variables, such as the VIX index and the oil price.

The ordering of economic activity, inflation and interest rates is standard in the monetary transmission literature. DenHaan and Sterk (2011) and Musso et al. (2011) order inflation before economic activity. However, ordering inflation after economic activity does not alter the results. I order the exchange rate and the trade balance to GDP after the real GDP, inflation and policy rate, as it is assumed that the exchange rate responds to changes in monetary policy, thus attracting capital flows. I order the Gini Index as the last variable, as changes in monetary policy affect the income distribution. Moreover, income inequality also results from currency appreciation/depreciation as high-income households also hold foreign assets.

Figure 7 reports the impulse responses function to an expansionary monetary policy in the SEACEN-8. The estimation is carried out over the period from 2000 until 2018. The Figure shows that an interest rate cut leads to an increase in real GDP, inflation, and exchange rate.6 Current account (percent of GDP) decreases and then increases after a few quarters. The depreciation of the exchange rate leads to a current account deficit in the short-term. Finally, the Gini Index decreases on impact. The Gini Coefficient indicates the dispersion of the income inequality, meaning that the Gini Index measures the degree of inequality in the distribution of family income in a country. The more nearly equal a country’s income distribution, the lower its Gini Index. Thus, the monetary policy shock in the PVAR appears to lower the degree of inequality. Therefore, lower interest rates and higher inflation tend to make the SEACEN-8 more equal income distributed.

Figures 8 and 9 compare the PVAR over two different periods: 2000-2007 and 2010-2018. The period just after the financial crisis has not been considered. The post-crisis period shows that a monetary policy shock leads to a more amplified increase in real GDP and inflation, coupled with a current account deficit on impact. On the other hand, the current account to GDP was increasing on impact during the pre-crisis period. Since 2010, the larger impact on real GDP led imports to increase relative to exports. Most importantly, the Gini Index appears to have the same response in the pre- and post-crisis period, both in sign and quantity. This suggests that the inflation and income channels have little impact on driving changes in income inequality. Indeed, during the post-crisis period, GDP increases about 3 times more than the pre-crisis period, and inflation increases only on impact and becomes negative after few quarters, while it always shows a positive response during the pre-crisis period before returning to zero after 2 years.

5. The lag has been selected following Andrews and Lu (2001) by choosing the smallest BIC, AIC and QIC based on GMM estimation.

6. The initial drop in real GDP growth is very puzzling. Due to large heterogeneity of economies included in the sample, such a drop can be due to some economies not showing a sudden increase in GDP for lower interest rate. Moreover, some economies such as Thailand, present large fluctuations in the stochastic volatility of real GDP, thus driving this odd result.
Figure 7

Figure 8
I focus next on asset prices and thus the PVAR model also includes equity prices and housing prices. Compared to the full period in which both equity price and Gini Index increase, the post-crisis period shows that an expansionary monetary policy leads to a small increase in equity prices followed by an initial decrease of the Gini Index, which then increases after few quarters. Moreover, the positive reaction of inflation is larger for the full period relative to the post-crisis sample, which contributes to a swell in increasing inequality, while the inflation response is contained in the post-crisis period, leading to a smaller impact in the Gini Index. This indicates that monetary policy affects the income distribution through asset prices. Indeed, when asset prices increase, the Gini Coefficient increases as well, indicating more income dispersion (see Figures 10 and 11).

Relative to equity prices, house prices tend to respond more to monetary policy shocks. Despite an initial drop in house prices, an expansionary monetary policy has the effect of boosting housing prices after a few quarters. The Gini Index initially decreases by about 3 percent and then rebounds, reaching a positive peak of about 1.5 percent in the third quarter. It seems that the Gini Index is largely influenced by housing prices and housing owners (see Figure 12).
Figure 10
Expansionary Monetary Policy Shock with Equity Prices (2000-2018)

Figure 11
Expansionary Monetary Policy Shock with Equity Prices (2010-2018)
Figure 12
Expansionary Monetary Policy Shock with Housing Prices (2010-2018)

Figure 13 reports the forecast error variance decomposition and shows the proportion of the unanticipated changes of a variable that can be attributed to innovations in the variable itself and to other variables in the system. The current account and monetary policy shocks explain about 34 percent and 17 percent of the variation of the Gini Index for the first period, respectively. Over a longer horizon, the current account and monetary policy shocks both explain about 26 percent of the fluctuations in the Gini Index. Inflation contributes to explaining fluctuations of the Gini Index by about 15 percent while other variables show a marginal contribution. On the one hand, trade openness and international capital flows are very important in terms of income inequality, probably because high-income households receive capital gains from investing in foreign assets. On the other hand, the action of central banks are also a key factor in explaining the fluctuations in income inequality.
The analysis further examines the responses of the level of income inequality to expansionary monetary policy shocks and whether the responses are influenced by high and low inflation regimes. Thus, the following Panel VAR model includes bands as follows: inflation below 2 percent and inflation above 2 percent. Two policy rate dummy variables are constructed to capture the changes in the policy rate constrained by where inflation may be at the time for each band.

The first policy rate dummy equals to the values of negative changes in the policy rate when inflation is below or equal to 2 percent and zero otherwise, while the second policy rate dummy is equal to the negative changes in the policy rate when inflation is above 2 percent and zero otherwise.

Figure 14 shows that an expansionary monetary policy shock has the effect of lowering income inequality only if inflation is not too low. Indeed, when inflation is below 2 percent, income inequality increases on impact. This is because borrowers do not gain with lower real debt repayment, while savers are better off. Moreover, the low inflation rates lead to higher unemployment rates and less bargaining power for workers to increase real wages.
5. DSGE Model

So far, most of the analysis has been carried out based on the Gini Index as a proxy for income inequality. However, it would be very interesting to understand what the income reactions to monetary policy for specific classes of households are. Due to data limitation for the SEACEN-8 region, it was not possible to collate time series data on income and wealth distribution over the quantile population, except for Chinese Taipei.\(^7\) Figure 15 shows that in Chinese Taipei about 40 percent of disposable income are held by the top 20 percent, while the lowest 20 percent hold less than 10 percent. Further, Figure 15 shows that disposable income has decreased over time for the bottom 60 percent of the population, while it has increased for the top 20 percent. In contrast, the third and fourth 20 percent show a constant disposable income over time. The question is whether monetary policy has contributed to decreasing incomes for the poor and the richest households.

Most models of the monetary policy transmission mechanism implicitly adopt this view by featuring a representative agent. By contrast, recent literature argues that redistribution is a channel through which monetary policy affects macroeconomic aggregates, because those who gain from accommodative monetary policy have higher marginal propensities to consume (MPCs) than those who lose. See Coibion et al. (JME, 2017), Kaplan, Moll and Violante (AER, 2018) and Auclert (AER, 2019).

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\(^7\) The rest of the SEACEN-8 economies are able to collect data on income and wealth distribution only for the most recent years based on survey data collected in 2013, 2015 and 2017. This prevents any time series analysis to be carried out.
In order to highlight the role of heterogeneity, I develop a model that focuses on two groups of households: (i) wealthier households, and (ii) poorer households. Wealthier households are financial investors who hold assets (government bonds, equity, and foreign bonds) and receive related income in addition to wages and transfers. These households usually belong to the middle/rich class and are commonly defined in the literature as Ricardian households. Poorer households are mostly asset-less households that only receive wage and transfer income. This group of households is defined in the literature as “hand-to-mouth” or Non-Ricardian households.

With this premise, I develop a dynamic stochastic general equilibrium (DSGE) model for a small open economy, following Medina and Soto (2007) and Punzi (2019). The model is characterized by two types of households: (i) Ricardian households which receive income from working, profits from firms and by holding domestic and foreign assets, and (ii) non-Ricardian households which receive only labor income. These households consume all their disposable income and have no savings. From the supply side, the model considers (iii) entrepreneurs that rent capital and labor from households, and combine them with energy input to produce differentiated intermediate goods; (iv) perfectly competitive firms that produce a final consumption good by combining intermediate goods supplied by monopolistically competitive firms; (v) a capital producer that rents capital from households and produces new capital from the existing capital stock; (vi) import goods retailers which buy intermediate goods abroad to re-sell at the domestic market; and, (vii) a monetary authority that sets nominal interest rates by following a standard Taylor Rule. The Appendix presents the basic model equations. Here I simply define the equation describing the net disposable income and wealth for the two types of households:

8. The theoretical model is also very similar to Smets and Wouter (2003, 2007) and Christiano et al. (2005).
• **Income Non-Ricardian Households:**

\[(1 - \tau) W_t N_t + TR_t - TAX_t\]

• **Income Ricardian Households:**

\[(1 - \tau) W_t N_t + \frac{i_t}{1 + i_t} B_t + e_t \frac{i_t}{1 + i_t} B^*_t + TR_t - TAX_t\]

• **Wealth Ricardian Households:**

\[B_{t-1} + e_t B^*_{t-1} + M_{t-1}\]

where \(W\) is the nominal wage, \(L\) is the number of hours worked, \(B\) is holdings of domestic assets, \(B^*\) is holdings of foreign assets, \(M\) is money, \(i\) and \(i^*\) are the domestic and foreign interest rates, \(e\) is the nominal exchange rate, and \(TR\) and \(TAX\) are government transfer and taxes.

Figure 16 reports the impulse response functions, expressed as percentage deviations from the initial steady state to a decrease in the policy rate, as described by the Taylor Rule. An interest cut stimulates investment, consumption and output. Inflation increases due to higher aggregate demand. Given the economic boom, firms increase labor input and real wages increase as well, while the wage share falls on impact, due to wage stickiness which raise firm profits. Indeed, real wages increase less relative to hours worked. The aggregate income and intertemporal substitution channels are clearly present as household interest rate cuts boost households’ consumption and firms’ investment (lower cost of external funds), leading to an increase in output, employment and wages. Further, higher wages and labor demand will produce additional income, boosting GDP even more.

The short-term real interest rate declines and the domestic currency depreciates in nominal terms. Due to the increase in labor income, consumption for both Ricardian and Non-Ricardian households increase, but the increase is more pronounced for Ricardian households. Income increases for both types of households, as well as wealth for Ricardians. Similar to consumption, income increases more for Ricardians. The exchange rate depreciations coupled with a large acquisition of foreign bonds enable the Ricardian households to become richer. Figure 16 shows that the distributional impact of monetary policy works through labor earnings, interest rate exposure and the Fisher channel. Figure 16 also shows the results based on different shares of households: the dotted line indicates equal share of households’ type; solid line considers only Non-Ricardian households, and circle line identifies only Ricardian households. The most interesting results concern total consumption, which would be higher if the economy were to be populated only by Non-Ricardians. This is not surprising as this group does not save, but use all its disposable income for consumption purposes. The next step is to connect this simulation with the findings on the Gini Index shown in previous section. In view of this, I calculated the deviations of the disposable income relative to the average disposable income in the economy, which are reported in Figure 17, top Panel. In the context of the assumption of only two types of households, the income deviation is a proxy to the Gini Coefficient, which measures the dispersion of income or wealth along a continuum of heterogeneous households. The Figure shows that the income shares for both households...
decline, and it takes a longer time for Non-Ricardians to return to the initial level relative to Ricardians. Moreover, although the deviations fall, indicating lower income inequality, the impact is more pronounced for Ricardians. Finally, the bottom Panel of Figure 17 shows that, with regard to Ricardian households, capital income share contribute more than the income share in increasing income. Thus, profits from firms and asset holdings explain the main increase in their income.

Figure 16
Expansionary Monetary Policy Shock (DSGE Model)
6. Ultra-Low Interest Rate

In Section 2, evidence was presented that in most of the SEACEN-8 region the short-term interest rate is well below the historical average, and very often such an environment is accompanied by low expected inflation. In particular, Chinese Taipei and Thailand have a policy rate close to 1.5 percent, which was kept constant for a very prolonged time. Clearly, these economies were avoiding extensive accommodative monetary policy to avert the reaching of the zero-lower bound.

This section aims at understanding the impact of income and wealth inequality when the policy rate is very low and resistant to change. In light of this, I consider the distributional impact of a temporary technology shock, comparing situations in which the short-term interest rate is free to fluctuate, with a situation in which it is not able to become negative. In so doing, the model needs to introduce a non-linear constraint where the interest rate is occasionally binding the zero-lower bound. Thus, the model is solved implementing the “Occbin” toolkit proposed by Guerrieri and Iacoviello (2015). The choice of simulating a temporary supply shock is motivated by the fact that some SEACEN economies have shown a moderate economic growth. In general, a supply shock leads to GDP growth and lower inflation. As the central bank’s goal is price stability, the central bank implements a loose monetary policy in order to bring inflation back to the initial target. This means that the
policy rate decreases, and demand is boosted, implying a further increase in GDP (see Figure 18, red dotted line). In the case of ultra-low interest rates, central banks avoid lowering the policy rate further in order to avoid a swift reaching of the zero-lower bound. This implies that central banks do not react to the temporary technology shock, and GDP increases by less relative to an unconditional case, and inflation also decreases by less.

**Figure 18**
Temporary Supply Shock (DSGE Model)

How does this less amplified response in GDP and inflation influence income inequality? Figure 19 shows that the ZLB prevents the necessary decrease in the short-term interest rate, thus leading to a less pronounced increase in investments. The lower impact on inflation allows real wages to decrease less, thus the supply of labor drop by less as well. The drop in labor income and the lower rates generate a drop in both households’ income. However, it would seem to be as if the income inequality has tended to decrease as the quantitative change of income for both households is almost the same. Moreover, by shutting down the interest rate channel, it seems as if income distribution is driven by income changes (i.e. labor income) and inflation.
In order to support the theoretical findings, I run a VAR model for the Chinese Taipei economy, comparing a full sample period with a period corresponding to low interest rates (from around 2010). Income for Ricardian households reflects the highest 20 percent of disposable income, while for Non-Ricardians, income is the average of the lowest 20 percent, second 20 percent, third 20 percent and fourth 20 percent of disposable income.

As the theoretical model predicts, the ultra-low interest rate allows GDP and inflation to change with less amplified responses to the technology shock. Income for Ricardian and Non-Ricardian households decrease, with the larger impact on Ricardians, meaning that inflation and labor income are affected more in this household class, relative to Non-Ricardian which can derive income from other sources of investment (see Figures 20 and 21).
Figure 20
Chinese Taipei - Temporary Supply Shock (Full Period)

Figure 21
7. **Conclusions and Policy Implications**

This paper analyzes the distributional impact of monetary policy on a group of SEACEN economies. While the impact of monetary policy on income and wealth inequality has been extensively discussed, very little research has been devoted to Asian economies. Moreover, after prolonged periods of stable inflation during the Great Moderation, researchers and policy makers have shown little interest on income and wealth inequality, but subsequent to the onset of the global financial crisis in 2007, the topic was revived, with particular focus on the role of central bank policies.

Using a Panel VAR estimation method, this study reveals that an expansionary monetary policy leads to a lower Gini Index, thus favoring lower income inequality for the group of SEACEN-8. However, asset prices have a large influence in determining the sign of the Gini Index. Indeed, the Gini Index decreases or increases following lower or higher housing prices. Thus, the distributional impact of monetary policy works mainly through the asset price channel. However, the inflation channel is found to be also very important: an expansionary monetary policy tends to decrease the Gini Index during the period when the inflation rate is larger than 2 percent, otherwise it tends to increase for lower inflation.

Finally, this study investigates the distributional impact of monetary policy during periods of ultra-low interest rates and low inflation. This is important as many SEACEN economies such as Chinese Taipei, Thailand and Vietnam have shown low and fixed policy rates in the recent period. This study shows that when there is a positive supply shock, the central bank is unable to cut the interest rate at the level it wishes, thus the expansionary effect on GDP is limited, as well as the impact on households’ income.

These results highlight the role of central banks in influencing income and wealth inequality. As many SEACEN economies have been using monetary policy to control inflation, in line with the principle of inflation targeting similar to many advanced economies, it would be important to consider if it would be beneficial to increase the target, or use alternative instruments, as the inflation channel is quite important in determining inequality in the SEACEN-8. Further, a booming housing market, that follows from an easing monetary policy, contributes to higher income and wealth inequality. Thus, the SEACEN-8 should pursue macroprudential policies to lean against the housing boom-bust cycle. Finally, even if the data availability is a constraint for a precise assertion, it can nonetheless be reported that the distributional impact of monetary policy in the SEACEN-8 arises from its heterogeneous impact on the value of agents’ income or wealth. Thus, the SEACEN-8 should collate better data on income and wealth across different households to properly understand who gains and who loses.
References


DSGE Model

I-1 Households

The domestic economy is populated by a continuum of identical economic agents, where a representative household derives utility from consuming goods, $C_t$ and from leisure, $l_t$. However, households’ heterogeneity is introduced through their income. Thus, the representative Ricardian household maximizes the following expected utility:

$$\max E_0 \sum_{t=0}^{\infty} \varepsilon_t^d (\beta^t)^t \left[ \ln(C_t) - \frac{vL_t}{\eta} (L_t)^{\eta} \right]$$

subject to the following budget constraint

$$P_t C_t + Q^e_t (K_t - (1 - \delta)K_{t-1}) + B_t + e_t E_t = W_t L_t + R_k^E K_t + R_{t-1} B_{t-1} + e_t \zeta_{t-1} R^*_t B^*_t$$

where $C_t$ is total consumption, and $L_t = 1 - l_t$ is the total hours worked. Households own capital and rent it to intermediate firms at the rental price $R_k^E$. $F_t$ are dividends that household receives from firms and $W_t$ is the nominal wage. $B_t$ are domestic and foreign bonds, which pay the domestic nominal interest rate, $R_t$, and the foreign nominal interest rate, $R^*_t$. $e_t$ is the nominal exchange rate. $\zeta_t$ represents the risk premium that domestic households pay when they borrow from the foreign country, and it is a function of the ratio of net foreign asset positions relative to GDP: $\exp \left[ \frac{\varphi (e_t E^*_t)}{Y_t} \right] = \zeta_t$, where $\varphi$ is the adjustment cost parameter. $v$ and $\eta$ are the weight of hours worked in the utility function and the inverse of the Frisch elasticity of work effort, respectively. $\varepsilon_t^d$ is a preference shock and it can be interpreted as a demand shock.

On the other hand, Non-Ricardian households maximize similar utility function subject to:

$$P_t C_t = W_t L_t$$

The total consumption is composed by a CES aggregation of standard consumption goods, $C^Z$, and energy consumption, $C^E$, such as:

$$C_t = \left[ \gamma_t^C \left( C^Z_t \right)^{\rho - 1} + (1 - \gamma_t^C) \left( C^E_t \right)^{\rho - 1} \right]^{\frac{1}{\rho}}$$

where $\gamma_t^C$ is the share of standard goods in total consumption, and $\rho_C$ denotes the elasticity of substitution between standard goods and energy. Energy includes oil, electricity, gas and coal. The optimal demands for the composition of total consumption are given by:

$$C^Z_t = \gamma_t^C \left( \frac{P^Z_t}{P_t} \right)^{-\rho_C} C_t$$

and

$$C^E_t = (1 - \gamma_t^C) \left( \frac{P^E_t}{P_t} \right)^{-\rho_C} C_t$$

where $P^Z_t$ is the price of standard consumption goods and $P^E_t$ is the energy price.
The total aggregate consumption price is given by \( P_t = \left[ \gamma C(P_t^Z)^{1-\rho_c} + (1-\gamma C)(P_t^E)^{1-\rho_c} \right]^{1/\rho_c}. \)

Moreover, standard consumption goods are composed by a CES aggregation of home goods, \( C^H \), and imported foreign goods, \( C^F \), such as:

\[
C_t^z = \left[ \alpha C^{1/\xi_c} \left( C_t^H \right)^{\xi_c - 1} + (1 - \alpha C)^{1/\xi_c} \left( C_t^F \right)^{\xi_c - 1} \right]^{\xi_c - 1},
\]

where \( \alpha_c \) is the proportion of domestic goods in total consumption, and \( \xi_c \) denotes the elasticity of substitution between domestic and foreign goods. The optimal demands for domestic and foreign goods are given by:

\[
C_t^H = \alpha_c \left( \frac{P_t^H}{P_t} \right)^{\xi_c} C_t^Z
\]

and

\[
C_t^F = (1 - \alpha_c) \left( \frac{P_t^F}{P_t} \right)^{\xi_c} C_t^Z,
\]

where \( P_t^H \) is the price of standard consumption home goods, \( P_t^F \) is the price of imported foreign goods, and \( P_t^z = \left[ \alpha C(P_t^H)^{1-\xi_c} + (1 - \alpha C)(P_t^E)^{1-\xi_c} \right]^{1/\xi_c}. \)

I-2 Capital Producers

Capital producers combine a fraction of the final goods purchased from retailers as investment goods, \( I_{k,t} \), to combine it with the existing capital stock in order to produce new capital goods. Moreover, part of the capital is rented to retailers at \( R_t^K \). Capital production is subject to an adjustment cost specified as \( \frac{\psi_k}{2} \left( \frac{I_{k,t}}{K_{t-1}} - \delta \right)^2 K_{t-1} \), where \( \psi_k \) governs the slope of the capital producer’s adjustment cost function. Capital producers choose the level of \( I_{k,t} \) that maximizes their profits

\[
\max_{I_{k,t}} Q_{k,t} I_{k,t} - \left( I_{k,t} + \frac{\psi_k}{2} \left( \frac{I_{k,t}}{K_{t-1}} - \delta \right)^2 K_{t-1} \right).
\]

From profit maximization, it is possible to derive the supply of capital

\[
Q_{k,t} = \left[ 1 + \frac{\psi_k}{\left( I_{k,t} / K_{t-1} - \delta \right)^2} \right],
\]

and \( q_t^k = \frac{Q_{k,t}}{P_t} \) is the relative price of capital. In the absence of investment adjustment costs, \( q_t^k \) is constant and equal to one. The usual capital accumulation equation holds

\[
K_t = (1 - \delta)K_{t-1} + I_{k,t}.
\]
I-3 Domestic Firms

Final Goods Domestic Sector
The model assumes there is a continuum of retailers indexed $f \in [0,1]$ who transform intermediate goods $Y_t(f)$ into a final consumption good sold at home, $Y_t^H$, and abroad, $Y_t^{HF}$, according to a constant elasticity of substitution technology:

$$Y_t^H = \left[ \int_0^1 Y_t^H(f)^{\frac{\varphi_{HF}}{\varphi_{HF}-1}} df \right]^{\frac{\varphi_{HF}}{\varphi_{HF}-1}},$$

and

$$Y_t^{HF} = \left[ \int_0^1 Y_t^{HF}(f)^{\frac{\varphi_{HF}}{\varphi_{HF}-1}} df \right]^{\frac{\varphi_{HF}}{\varphi_{HF}-1}},$$

where $\varphi_H$ and $\varphi_{HF}$ are the elasticity of substitution between intermediate goods sold at home and abroad, respectively.

From standard cost minimization it is possible to derive the input demand for intermediate goods $f$ at home and abroad:

$$Y_t^H(f) = \left( \frac{P_t^H(f)}{P_t^H} \right)^{-\varphi_H} Y_t^H,$$

and

$$Y_t^{HF}(f) = \left( \frac{P_t^{HF}(f)}{P_t^{HF}} \right)^{-\varphi_{HF}} Y_t^{HF}.$$

The price indices are aggregations of the price of intermediate goods:

$$P_t^H = \left[ \int_0^1 P_t^H(f)^{1-\varphi_H} df \right]^{\frac{1}{1-\varphi_H}}$$

and

$$P_t^{HF} = \left[ \int_0^1 P_t^{HF}(f)^{1-\varphi_{HF}} df \right]^{\frac{1}{1-\varphi_{HF}}}.$$

Intermediate Domestic Sector
Intermediate home goods are produced according to the following equation:

$$Y_t^I(f) = \xi_t^Y \left[ \alpha_H^{1/\xi_H} [I_t^{1-\alpha} K_t^\alpha]^{\xi_H-1} + (1 - \alpha_H)^{1/\xi_H} (E_t^I)^{\xi_H-1} \right]^{\xi_H^{-1}},$$

where $E_t^I$ is energy input used in the production function, combined with labor and capital. $\xi_t^Y$ is the transitory productivity shock. The parameters $\alpha$ and $\alpha_H$ define the share of capital and the share of energy inputs, while $\xi_H$ is the elasticity of substitution between energy inputs and productivity factors.
Intermediate firms are owned by households, and they are monopolistically competitive and minimize cost, such that the nominal marginal cost is equal to:

$$MC^H(f) = \frac{W_tL_t(f) + R^K_tK_t(f) + P^E_tE^H_t(f)}{Y^H_t(f)}$$

The model assumes a Calvo price-setting mechanism and intermediate goods firms adjust each period their prices with a probability $(1 - \theta)$. $(P^H_t)^*(i)$ is the price that retailers are able to adjust. Thus, intermediate goods firms maximize the following expected profit:

$$\max E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \left[ P^H_t(f) - MC^H_{t+k}(f) \right] Y^H_{t+k}(f)$$

and

$$\max E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \left[ s_{t+k} P^H_F(f) - MC^H_{t+k}(f) \right] Y^H_{t+k}(f)$$

where $\Lambda_{t,t+k} = \beta^{t+k} \frac{U_{C+k} P_t}{U_{C_t} P_{t+k}}$.

Intermediate goods domestic firms maximize the expected profit subject to the input demand and the production function. Then, the optimality condition for prices $P^H_t$ and $P^H_tF^*$ are:

$$E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \left[ P^H_t(f) - \frac{\theta^H}{\theta^H - 1} MC^H_{t+k}(f) \right] Y^H_{t+k}(f) = 0$$

and

$$E_t \sum_{k=0}^{\infty} \theta^k \Lambda_{t,t+k} \left[ s_{t+k} P^H_tF^*(f) - \frac{\theta^H_F}{\theta^H_F - 1} MC^H_{t+k}(f) \right] Y^H_{t+k}(f) = 0$$

I.4 Import Goods Retailers

Similar to Medina, Soto, et al. (2007), the model imposes incomplete exchange rate pass-through into import prices in the short-run by introducing local currency price stickiness, such that the expenditure switching effect of exchange rate movements can be mitigated.

The model assumes there is a continuum of import goods retailers indexed $z \in [0,1]$ who transform intermediate goods $Y^F_t(z)$ into a final consumption good $Y^F_t$, and the demand for import goods $z$ is given by:

$$Y^F_t(z) = \left( \frac{P^F_t(z)}{P^F_t} \right)^{-\theta_F} Y^F_t,$$

where $P^F_t(z)$ is the domestic-currency price of imported goods $z$ and $P^F_t$ is the aggregate price of imported goods in the domestic market, while $\theta_F$ is the elasticity of substitution of imported goods.
Import goods retailers buy intermediate goods abroad to re-sell at the domestic market. They have a monopolistic power, and adjust their prices with a probability of \((1 - \theta_F)\) each period. For simplicity, the model assumes that \(P^{F*}_t(f) = P^{F*}_t\), and import goods retailers choose the price that maximizes the following expected profits:

\[
\max E_t \sum_{k=0}^{\infty} \theta_F^k \Lambda_{t,t+k} \left[ P^F_t(f) - s_{t+k} P^{F*}_{t+k}(f) \right] Y^{F}_{t+k}(f),
\]

This setup allows the exchange rate pass-through to be incomplete in the short run.

**I.5 Monetary Policy**

The Central Bank follows a Taylor-type rule that reacts to changes in inflation and output:

\[
\frac{R_t}{\bar{R}} = \left( \frac{R_{t-1}}{\bar{R}} \right)^{\phi_R} \left( \frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi(1-\phi_R)} \left( \frac{Y_t}{\bar{Y}} \right)^{\phi_Y(1-\phi_R)} \epsilon_{R,t},
\]

where \(\phi_\pi\) is the coefficient on inflation in the feedback rule, \(\phi_Y\) is the coefficient on output, and \(\phi_R\) determines the degree of interest rate smoothing. \(\epsilon_{R,t}\) is an i.i.d. monetary policy shock.

**I.6 Aggregate Equilibrium and the Real Exchange Rate**

Domestic output, \(Y_t\), can be consumed, invested or exported

\[
Y_t = P_tC_t + Q_k I^k_t + N X_t
\]

Net exports equals:

\[
N X_t = \left[ \epsilon_t(P^{H,F}_t Y^{H,F}_t) \right] - \left[ \epsilon_t(P^F_t Y^{F}_t + P^{E*}_t (C^E_t + E^I_t)) \right]
\]

The real exchange rate is given by:

\[
\epsilon_t = \frac{\epsilon_t P^{*}_t}{P_t}
\]

Moreover, the model assumes the supply of energy is completely elastic at any given price, therefore the law of one price hold, and the price of energy in domestic currency is given by:

\[
P^{E}_t = \epsilon_t P^{E*}_t.
\]
I.7 Calibration

This section calibrates parameters for a small open economy, and I use long-run statistics for a small open economy in emerging Asia. Most of the parameters are picked from Kim and Loungani (1992), Huang (2005), Chang, Liu, and Spiegel (2015) and Zhao, Zhang, Wang, and Xu (2016).

The discount factor, $\beta$, is set equal to 0.985 to match the annual average deposit interest rate of around 4.35 percent in the steady state. The labor disutility, $\nu^L$, and the labor preference, $\eta$, parameters are 1 and 2, respectively. The adjustment cost on risk premium is set equal to 0.001 as in Schmitt-Grohe and Uribe (2003).

The share of standard goods in total consumption, $\gamma_C$, and the share of home goods, $\alpha_C$, are set equal to 98.5 percent and 65 percent. The elasticity of substitution between standard goods and energy, $\rho_c$, is equal to 0.30: these parameters aim to match the low elasticities of demand for energy as in Arnberg and Bjørner (2007) and to match the ratio of the unit GDP energy consumption in Asia during 2005 of 2 percent. As in Chang, Liu, and Spiegel (2015), the elasticity of substitution between domestic and foreign goods, $\xi_c$, is set to 0.80 to match the average import-to-GDP ratio in Asia between 1990 and 2009 of 20 percent. As in Zhao, Zhang, Wang, and Xu (2016), the depreciation rate of capital, $\delta$, is equal to 0.025 and the capital share in production, $\alpha_H$, is 0.3 which both imply a share of investment to GDP equal to 0.393. The Calvo parameter for nominal rigidity, $\theta_a$, is set to 0.85 and the monetary policy parameters $\phi_{\pi}$, $\phi_r$ and $\phi_Y$ are equal to 0.14, 0.9 and 1.159.

Similar to Medina, Soto, et al. (2007), I set the elasticity of substitution between intermediate goods sold at home and abroad equal to 11 and the elasticity of substitution between energy inputs and productivity factors, $\xi_H$, is equal to 0.3 and its share in the production function is 0.01. Moreover, these values help to match the ratio of energy used in the production function to GDP, $E/Y$, in Asia during 2005 of 2.8 percent.